Asia Science Letter

Information Bulletin of the Asian Office of Aerospace Research and Development Tokyo, Japan

ASL Volume 21 **Sep-Oct 99**

Highlights

News: Information Directorate Visits Singapore and Japan; 17-29 April 1999:

A team from AFRL/IF, SAF/IAQ/AQRT, and AOARD visited Singapore on 17-23 April to assess information technologies and cooperative opportunities with Singapore under the new Master Information Exchange Agreement (IEA). The AFRL/IF team consisted of Lt Col Paul Phister (AFRL/IFB), Dr. John C. Cleary (AFRL/IFG), LtCol. Steve Petersen (SAF/AQRT), Mr. David Gressman (SAF/IAQ), and Ms. Joanne Maurice (AOARD).

The team met Mr. Herbert Schulz, the Deputy Chief of Mission at the U.S. Embassy, to discuss the overall purpose of the visit. Ms. Rebecca Lumley, Office of Defense Cooperation, US Embassy arranged the subsequent itinerary. The team was briefed by Dr. Quek Gim Pew, Director of the Singapore Armed Forces Directorate of Research & Development and visited the Defense Material Organization and the National Science & Technology Board. The following universities and laboratories were also visited: DSO National Laboratories, Nanyang Technological University (NTU), Institute for High Power Computing (iHPC), Kent Ridge Digital Lab (KRDL), Institute of Microelectronics, National University of Singapore's Centre for Remote Imaging, Sensing, and Processing, Singapore's Advanced Research and Educational Network, Centre for Wireless Communication, the Gintic Institute of Manufacturing Technology, and the National Computer Board (NCW). [NTU, iHPC, and KRDL were discussed in the January 1999 and October 1998 ASLs. Future ASLs will feature more details on the other organizations.]

Singapore's modern infrastructure, "cutting-edge" technical facilities, and openness to international cooperation impressed the team. Of the numerous opportunities identified for cooperation, several specific areas were discussed: (1) 3-D immersive virtual reality chamber (CAVE), (2) information fusion in the areas of dynamic modeling and situational awareness, (3) natural language processing for text and table recognition, (4) image on demand, especially in the area of adaptively transmitting sub-sections of imagery, and (5) on-the-move mobile awareness where the system minimizes bandwidth requirement.

The team moved on to Japan on 24-29 April to explore possible research ideas on information systems science and technology. They visited the Advanced Telecommunications Research (ATR), the Communications Research Laboratories (CRL), and the NHK (Japan Broadcasting Corporation) laboratory.

Continued on page 2

Areas of interest include (1) speech recognition/translation - development of a Universal Voice Translator, (2) development of a large plasma screen for use with the Deployable "Data Wall", and (3) chaos communications technology, especially in the areas of multiplex synchronization and data hiding with chaotic oscillators. The team met with representatives from industry (Mitsubishi Electric Corporation and Toshiba, Electronic Systems Division) and the Japan Association of Defense Industry in preparation for the JADI planned visit to the United States in September 1999. [ATR and CRL are discussed in the January 1999 ASL. Future ASLs will feature the other organizations listed.]

(POC: Lt Col Paul Phister, AFRL/IFB, (315) 330-3315, phisterp@rl.af.mil) (Lyons & Maurice)

News Briefs

News Item: Japan Association of Defense Industry (JADI) to visit USAF & AFRL/IF, 13-20 Sep 99

A group of about 20-30 Japanese corporate executives representing JADI will visit the AF Aerospace Technology Exposition in Washington, DC, and AFRL sites in Rome and Dayton. Every two years, the JADI group sponsors a visit to the US for its industry representatives to attend defense symposia and visit facilities. This visit will focus on the USAF since the last visit focussed on the Army. The visit will provide wonderful opportunities for pursuing cooperative activities in Asia.

JADI is a non-profit organization incorporated in 1988 as a legal entity for public benefit. It is sanctioned by the Japanese Government (MITI and JDA). The Association's objective is to contribute to the establishment of the basis for national security by 1) promoting R&D and upgrading the industrial technologies of defense equipment for modernization and high-performance and 2) encouraging a moderate and steady growth of the defense industry. About 170 domestic firms are registered with the Association as regular or associated members. They represent a majority of the firms engaged in the manufacture, repair or trade of defense equipment and related products. JADI is a major defense-related industry association in Japan.

To implement its objectives, Association activities include 1) conducting surveys and studies for R&D defense equipment technologies, 2) reviewing specifications, manuals, and regulations, 3) providing seminars and lectures on MITI/JDA-administration-related advanced technologies themes, and 4) promoting cooperative relations with other defense-related public organizations. Its activities support and cooperate with the government in the export control of defense equipment products. Publications include the monthly "Gekkan JADI" and the JADI annual report. (Maurice)

Quarterly Review Engineer and Scientist Exchange Program (ESEP), Chatillon, France, 1 June 99

Kathleen Zyga, the only ESEP researcher in AOARD's region, works for Australia's Department of Defence Defence Science and Technology Organisation (DSTO), Tactical Surveillance Systems Division, in Salisbury, South Australia. She is working on the Ingara radar system. (Ingara means "long way" in Australia's aborigine language.) Although Australia generally does not face the threat of a large invasion, it does have a significant problem with small infiltrations, such as illegal immigration and drug running. Ingara is being developed to help Australia combat these infiltrations. Ingara has Spotlight and Stripmap Synthetic Aperture Radar (SAR) modes and can perform GMTI. Littoral surveillance trials have been conducted. Kathleen is currently working on Sea Clutter Analysis- looking at the reflectivity of the sea itself in order to detect small boats in different types of sea clutter. Future work includes completion of the littoral data analysis and land surveillance in the Northern Territories in order to achieve moving target recognition. (Gaudreault and Zyga)

Space & Communications

Feature Article: Development of Phased Array Systems in Japan

Over the past 20 years, research and development of radar with phased array antennas has been conducted as a collaborative effort by Japan Defense Agency's Technical Research Development Institute (TRDI), Mitsubishi Electric Company, Toshiba and NEC. TRDI has focused on conformal antennas for aircraft applications including spherical surface type (Mitsubishi), multi-curved surface type (Toshiba), and asymmetric columnar surface type (NEC). All receiving antenna patterns are formed using digital beam forming technique (DBF). [Requests for detailed information on the defense applications must be submitted through the US embassy.]

In addition to military applications, R&D activities also target space satellite systems. For example, large deployable antennas for phased array systems have been developed by NASDA for the Engineering Test Satellite VIII (ETS-VIII). Phased array systems for satellite communication are based on concurrent operations of TX/RX and simultaneous treatments of multiple frequencies. These systems are complicated when compared to conventional radar systems and have many technological barriers to overcome. Recent Japanese research activities are moving toward development of a DBF antenna through conventional phased array and active phased array systems. Each antenna element includes Low Noise Amplifier (LNA), High Power Amplifier (HPA), up/down converter, and A/D and D/A conversion circuits. Moreover, adjustment of the base band signal enables multi-beam operation (space division multiple connection), passing the input signal automatically while rejecting interference signal adaptively. This is made possible by recent progress of Ultra Large Scale Integrated (ULSI) circuits such as Digital Signal Processor (DSP). The Advanced Space Communications Research Laboratory (ASC) has been developing a new array system for the communication satellite in collaboration with NASDA. The following applications to satellite equipment are in progress.

1) ETS-III is an advanced satellite being developed primarily to establish and verify the world's largest geo-stationary satellite bus technology, which is necessary for space missions at the beginning of the 21st century. One of its five main objectives is S-Band Mobile Satellite Communication System and S-Band Mobile Satellite Broadcasting System Technologies. The following devices are being developed.

a) Active-Phased-Array Feeder: The transmission side feeder element consists of 31 solid state power amplifiers (400W in gross output), the receiving side feeder element has 31 low noise amplifiers. Signals from each feeder unit are synthesized into several beams covering the entire nation of Japan (450km per beam times 9 beams).

b) On-Board Processor: An On-Board Processor for cellular phone systems with the switching capacity of 500 channels and high-speed packet switching for data communications is being developed.

2) Gigabit Satellite Communication Program. A gigabit satellite will be launched in 2003 to set up high bit-rate transmission technology of 2 Gbps. The 30/20 GHz (Ka-band) frequency range has been selected. More than 2 fixed beams and more than 3 scanning beams are assumed.

3) Advanced Land Observing Satellite (ALOS). The ALOS will be launched by H-IIA launch vehicle in 2002. The ALOS has three remote-sensing instruments:

a) For digital elevation mapping, the Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM)

b) For precise land coverage observation, the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2), and

c) For day-and-night and all-weather land observation, the Phased Array type L-band Synthetic Aperture Radar (PALSAR). PALSAR is an active microwave sensor that provides higher performance than the former SAR.To obtain a wider swath than the conventional SARs, the sensor is beam steerable in elevation and the ScanSAR mode. Table 1 summarizes specifications of PALSAR.

Table 1. Major Specifications of PALSAR

Observation Mode	Fine Resolution Mode	Scan SAR Mode
Frequency	L-Band	
Polarization	HH or VV (Option: HV or VH)	
Spatial Resolution	10m (2 looks) 20m (4 looks)	100m
Swath Width	70km	250-360 km (3-5 scans)
Off-nadir Angle	18-48 degrees	
S/N	25 dB	
NE σ^o	-25 dB	

For more information on phased array antennas, contact Dr. Y. Watanabe (email: watanabe@asc.co.jp). (Miyazaki)

Site Visit: Advanced Space Communications Research Laboratory (ASC), Tokyo, Japan, 1 July 99

Established in 1994 as a consortium based on the Japan Key Technology Center (JKTC) financially sponsored by the Ministry of Posts and Telecommunication (MPT), the Ministry of International Trade and Industry (MITI), and twenty other leading-edge technology companies, ASC is developing a new phased array radar system for communication satellites in collaboration with the National Space Development Agency of Japan (NASDA). The total budget will be 8.4 billion yen over the 7-year duration of the project (through February 2001).

ASC seeks to promote development of highly sophisticated satellite communication and broadcasting systems by conducting R&D in key areas including:

- Large deployable antenna (10 m diameter) in geostationary orbit for miniature earth terminals in mobile satellite communication and broadcasting systems;
- High power transponders (over 400 W) to enable use of hand-held terminals in satellite communication and broadcasting systems;

- Large-capacity, on-board processors to provide efficient channel capacities use in mobile satellite communication systems employing multibeam technology; and
- Miniature mobile earth terminals (hand-held portable and vehicle-mounted terminals) to allow communications anytime, anywhere, by anyone.

For more information on ASC, contact Dr. Y. Watanabe (e-mail: watanabe@asc.co.jp). (Miyazaki)

Study and Workshop: Update on Wireless Communications in Japan and Europe, World Technology Educational Center (WTEC)

With the rapid development of underlying technologies for wireless communications, opportunities for new and improved services are being created. Far beyond . important emerging applications such as personal communications and mobile Internet services, is realization of applications as diverse and beneficial as telemedicine, GPS, intelligent transportation systems, deep space exploration, distance learning, wireless virtual university, and wireless access to digital libraries. Although U.S. companies currently dominate the world market for communications technologies, ambitious new R&D efforts underway in both Japan and Europe will likely contribute to the continuing erosion of U.S. competitiveness in next generation wireless technology.

For these reasons, WTEC surveyed wireless communication technologies in Europe and Japan. The scope of the US government-sponsored study was the pre-competitive long-term prospects for advances in wireless technologies and new applications and services. The study 1) identified R&D needs and technological opportunities that will enable next-generation wireless multimedia communications, and 2) addressed the critical technical breakthroughs needed to enhance the capacity, performance, convenience, and economics. Sponsors include NSF, NIST, DARPA, NASA, and DOD. Research areas examined were:

- device technologies, antennae and propagation
- beamforming, steering, and tracking
- signal-processing algorithms and IC chip architectures
- modulation and demodulation, coding and decoding
- channel access, power control, and signal formatting
- switching, routing, mobility
- compression, mutimedia
- network architectures and services

Non-technical topics include:

- funding for industry and government R&D programs,
- cooperation between industry and government research teams,
- international cooperation,
- R&D methodology (management strategy, etc.) and
- research infrastructure and education.

Results of the combined Europe-Japan study will be publicly debriefed by panelists at the WTEC Workshop on Wireless Technologies and Information Networks, convening 9 Sep 99. Information is posted on the web at http://itri.loyola.edu/wireless/ (Maurice)

R&D Report: Dynamic Analysis of Solar Arrays Equipped with Strain Energy Hinges, Prof. Moon Kyu Kwak, Dongguk University, Seoul, Korea:

This study examined dynamic problems related to the deployment dynamic analysis of solar arrays equipped with strain-energy hinges (SEH) using thin metallic strips. The dynamic behavior of the fully deployed solar array structure largely depends on the stiffness property of the yoke and the SEHs. Due to its structural simplicity, the SEH has been considered as an alternative to the torsional spring type deployment mechanism. Series of buckling and deployment tests on a single SEH and a solar array structure equipped with SEH have been conducted. The deployment test results showed there were residual vibrations after deployment that resulted from the rapid deployment and bending flexibility of the SEH. These vibrations can dampen to the stable configuration but may result in overshoot due to heavy inertial loading.

For better deployment and to reduce this effect, Prof. Kwak used the viscoelastic strain-energy hinge (VSEH). The VSEH is made of strip measures and embedded viscoelastic material. Experimentation verified that the embedded viscoelastic material between the strips resulted in smooth deployment but the residual vibrations were not reduced by the VSEH. Further buckling tests showed a reduced buckling load and increased natural damping. Since the fully deployed solar array structure behaves like a cantilever, residual vibrations are most affected by the stiffness of the yoke. Therefore, active damping technology is needed to actively suppress residual vibrations. The use of the VSEH in a realistic space environment still needs to be investigated. The Final Study Report is available at AOARD. (Kim)

Conference: 41st Japan Society of Mechanical Engineers (JSME)/Aeronautical and Space Sciences Japan (JSASS) Annual Meeting, Sendai, Japan, 14 July 99

This annual meeting, held at Tohoku University, was attended by about 80 delegates. Prof. Masayoshi Esashi from the New Industry Creation Hatchery Center gave a keynote address "Sensors and Micromachines Fabricated by Applying Semiconductor Microfabrication." He presented developments in silicon etching for precise micromachining. Ceramic microstructures were fabricated using micromachined silicon (Si) as a mold. Both Si and Gallium Arsenide (GaAs) microelements exhibit very high strength with average bending and fracture stress of 4 and 2 Gpa, respectively and max fracture stress of 4 GPa. This is compared to a high steel value of 0.8 Gpa. Advanced microsensors and micromachines have been realized based on silicon micromachining. Active catheters that move in wave motion using distributed microactuators have been developed. Capacitive sensors (electrostatic actuators) are being used in applications such as pressure sensors and gyros. Additionally, Tohoku University has developed electrostatically levitated micromotors for inertia measurement systems.

Papers related to the next generation Japanese reusable launch vehicles and composite cryogenic propellant tanks and thermal protection systems (TPS) were well represented. The application of composite materials to cryogenic tanks is considered essential for practical reusable space transportation. Dr. Takashi Ishikawa of the National Aerospace Lab and Dr. Takahira Aoki of Tokyo University are the leading investigators for initial composite tank development. Current research is investigating suitable materials for cryogenic storage and leak detection caused by microcracks and voids in the structure. Dr. Kunihiko Ohtake of National Aerospace Laboratory presented a fitting method for the TPS/Main frame assembly. His method allows a vacant space (4mm) between TPS tile and main frame skin by cutting a stress relief felt. Computer heat conduction simulations showed a 15% decrease in temperature.

This annual congregation of Japanese researchers from many engineering disciplines may lead to breakthrough aerospace technologies that reduce costs and meet mission requirements. (Kim)

Site Visit: Doshisha University, Mechanical Engineering and Systems, Tanabe Campus, Kyoto, Japan, 25 June 99

Joseph Hardy Neesima, who stowed away on a ship bound for America to become the first Japanese citizen to obtain an academic degree overseas, founded Doshisha University in 1875. This private university with a yearly budget of $250 million has 22,600 undergraduate, 2,000 graduate students and 950 instructors serving many disciplines such as Theology, Law, Commerce, Letters, Economics, and Engineering at its three campuses. The Faculty of Engineering is located on Tanabe Campus and has seven departments - Computer, Electrical, Electronics, Mechanical, Energy, Molecular Science, and Chemical.

Prof. Toru Fujii, who heads Advanced and Composite Materials, currently manages fifteen on-going research projects ranging from the feasibility of bamboo fiber reinforced composites to a study on thermoplastic deformation for one piece brake disks. Prof. Fujii's main interest is in the durability of composite materials, especially the study of fatigue properties under various environmental conditions (humid or dry). There is a need to predict long-term degradation due to mechanical and environmental effects when composite materials are used in various civil and aerospace applications. For example, under uniaxial tension loading, many theories for fatigue life based on continuum damage mechanics exist. Presently, there are no theories to predict fatigue life of composites subject to tension/torsion biaxial loads. Prof. Fujii fabricated thin-walled glass fabric/polyester composite tubular specimens and subjected them to biaxial pulsating loads (triangular wave). Biaxial cyclic loads were applied proportionally. The effect of the loading path on the fatigue life at biaxial stress was examined. The results show that structural modulus decreases significantly during the first cycle and decreases steadily until failure of the tube. (Kim)

Site Visit: Advanced Materials Science Research & Development Center at Kanazawa Institute of Technology (KIT), Kanazawa, Japan, 23 June 99

Prof. Yasushi Miyano and Prof. Masayuki Nakada manage the Materials System Research Laboratory which specialized in the durability of composite materials. Durability evaluation includes time and temperature dependent life predictions, design allowables, and biaxial effects. Recognizing the challenge for composite materials users to design a structure to meet the anticipated load due to the environmental effects, the laboratory has developed a tensile test machine capable of testing a single fiber

strand in a temperature controlled chamber. This unique composite testing and evaluation laboratory has the capability to analyze composite specimen durability over more than two years. Prof. Miyano's group has reported that various composites exhibited fracture modes of flexural static, creep, and fatigue strength that were consistent over a wide range of time-temperature dependent conditions. Additionally, the tensile failure load of a conically shaped joint system for fiber reinforced plastic (FRP) was studied using tension tests for static, creep and fatigue loading. Using this data, the group expects to develop a simpler estimation of the life cycle of polymer composites and its structures. (Kim)

Site Visit: Kyoto University, Graduate School of Engineering, Department of Polymer Chemistry, Kyoto, Japan, 24 June 99

Founded in 1897, Kyoto University has the largest number of research institutes (13) and centers (17) of any university in Japan. With over 2,700 instructors and 21,000 students enrolled (7,000 graduate students) this University has produced four Nobel laureates, more than any single university in Japan.

Prof. Dr.Takeji Hashimoto was an Exploratory Research for Advanced Technology (ERATO) Director from 1993-1998. This 5-year project's main research focus was on the phase behavior or phase separation process of polymers. The term "Polymer Phasing" was coined and it refers to studies of mesoscopic pattern formation in self-organization processes via phase transitions and phase separation in multiphase polymer systems. The objective was to explore the space-time organization processes through both in-situ and real-time experimental observations and theoretical computer simulations. This resulted in the development of new materials with novel structures. Polymer blends, block copolymers, gels and ionic colloidal dispersions were employed as model systems having large and long fundamental lengths and time scales. The ERATO project demonstrated for the first time 3D digital images of phase-separating binary polymer mixtures, which were constructed with nearly equal phase volumes and nearly equal molecular weights. The images were found to be bicontinuous and to have characteristics of a "sponge-like" structure found for microemulsions. This research has contributed to the field of critical phenomena and was proven to be ideal for studying phase-separating binary mixtures of simple liquids.

Prof. Hashimoto also investigated novel nano-scale structures. He used the microphase separation of block copolymers to selectively degrade one of the microdomains to create unique materials containing regularly spaced networks of holes. These holes (nanodomains) were further selectively deposited with nanoparticle metals to produce polymer/metal hybrid structures. The results from these projects might uncover new functional semiconductors and bi-continuous structures.

Exploratory Research for Advanced Technology (ERATO): In 1981, the Research Development Corporation of Japan (JRDC), predecessor of the Japan Science and Technology Corporation (JST), initiated an innovative research program called ERATO. The purpose was to create future interdisciplinary scientific activities and search for better systems to carry out basic research in advanced science and technology. Within the ERATO program, the JST role is to select prominent researchers (Directors). The Directors are responsible for setting up research plans and selecting key individuals usually recent graduates from advanced degree programs from industry, academia, government, and overseas. Members of project teams are employed by JST for two to five years on a yearly renewable contract.

Each project team comprises between 15 and 20 scientists usually grouped into 3 subteams. Including the supporting staff, most projects involve about 25 persons. All projects are funded at around ¥1.7 billion (on the order of US$16 million) for five-year project lifetimes. JST administers and fully funds the ERATO program. The fields of research are broad and concern many unexplored and precompetitive regions of science and technology. Projects that are fashionable or trendy are eliminated in preference to those that are emerging and challenging. Research is carried out in rented laboratories located in universities, industry, and other institutions. JST has no research facilities of its own, but provides the Directors with administrative and other support. JST promotes transfer of research results to industries to help foster new industry. Results of the project are the shared property of JST and the researchers. A patent right may be shared 50/50 between JST and the project team. The portions of the patent right belonging to members can be transferred to their home institutions upon the termination of the project. (Kim)

Electronics & Optics

News: Visit by AFRL/DE Scientist to Central Research Laboratory of Hamamatsu Photonics, Hamamatsu, Japan, 11 June 99

Dr. Mark Gruneisen (AFRL/DE) visited Hamamatsu Photonics to discuss the possibility of modifying their Electrically Addressable Spatial Light Modulator (SLM) Module for an adaptive optics experiment. The SLM uses a parallel-aligned nematic liquid crystal for phase modulation and an amorphous silicon layer as an optically addressable media. SLM is integrated with an electrically addressable liquid crystal display. Unlike other electrically addressable devices, SLM module is non-pixelated, minimizing optical noise caused by diffraction effect.

Accompanied by Koto White of AOARD, Dr. Gruneisen met with Dr. Tsutomu Hara (Research Section Manager) and Mr. Yuji Kobayashi (Senior Researcher). Dr. Hara's group has developed a compact fingerprint verification system based on the SLM. They are using it to permit access to their laboratories in place of an ID card. Dr. Hara's other project is to develop lasers with tunable wavelength from ultraviolet to infrared. A solid state laser with tunability from 410nm to 2550nm is near commercialization. The group grows their own nonlinear crystals, such as beta-BaB_2O_4 (1 cm^3 size and good quality) for optical parametric oscillation. As a part of the project, they conduct coordinated research on crystal growth, processing technique, multi-layer dielectric coating, and the resulting optical devices. They are targetting the scientific instrumentation markets in information, medical, and environmental technologies.

Hamamatsu Photonics is a multi-national entrepreneurial company with $100M capital and 2000 employees that has kept close ties with science and technology efforts of the Japanese Government throughout the years. The company is best known for cutting-edge scientific instruments such as femtosecond streak cameras and a single photon imaging device. They are also involved in large national science projects such as "Super Kamiokande" to measure the mass of the neutrino (they fabricated the world largest photomultiplier tube array), Positron Emission Tomography Center for mind/brain science, and nuclear fusion project (they fabricated high power diode laser).

Hamamatsu Photonics, formerly Hamamatsu TV Company, was founded in 1953 by one of the students of Prof. Kenjiro Takayanagi, a known pioneer of television technology in Japan. He succeeded in projecting a still image (of a Japanese character) onto a cathode-ray tube in 1926, and by 1935, developed an electronic television transmission. (White)

Conference: InterOpto'99; Makuhari Messe, Chiba, Japan; 13-16 July 99:

The 14^{th} Optoelectronic Technology Exhibits (InterOpto'99) was organized by the Optoelectronic Industry and Technology Development Association (OITDA). This year, exhibitors included 140 domestic and 87 foreign companies. Participants were estimated to be 80,000 (almost the same as last year). A feature of the exhibits was an increase in the optical communication areas especially software for optics and manufacturing equipment for optical components. The exhibits have become more specialized for components and equipment with optical communication exhibits continuing to decrease due to a reduction of participants in this area. Demonstrations from optical fiber companies and optical connecting components were shown. Optical measurement equipment and various kinds of light sources from typical equipment companies were also demonstrated. One of the highlights was the exhibit on Plastic Optical Fiber (POF) from the POF consortium.

Seminars were given by 23 exhibitors. 10 Gbps high speed optical communication and Dense Wavelength Division Multiplexing (DWDM) communication systems were the main topics. Seminars included U.S.-Japan Joint Optoelectronics Project (JOP) workshop (13 Jul), Optoelectronic Industry Trend Seminar (14 Jul), Optoelectronic Industry Venture Business Seminar (15 Jul) and Optoelectronic Technology Trend Seminar (16 Jul). In the JOP workshop, high performance tunable Laser Diode (LD) for Wavelength Division Multiplexing (WDM) and optical amplifier for WDM were reported. Trend seminars were based on annual summary reports by survey committee members under OITDA. Optical communication technology, industrial laser and flat display technology were the main topics. Detailed proceedings and CD-ROM will be distributed later.

At the same time, related conferences were held; Femto Second Technology (FST'99), Micro Optics Conference (MOC'99), and International Plastic Optical Fiber (POF) Conference '99. These will be described in subsequent ASLs. For more information on InterOpto'99, contact Mr. Y. Ono of OITDA (email: yono@ oitda.or.jp). (Miyazaki).

Conference: 5th International Conference on Electrical Transport Properties of Inhomogeneous Media (ETOPIM5), Hong Kong, 21-25 June 99

Over 100 researchers from Europe, North America, South Africa, Asia, and the Middle East participated in ETOPIM5 in Hong Kong. The Physics departments of four Hong Kong universities and the Physical Societies of Hong Kong and China organized the conference with a focus on the fundamental issues and applications of electro-magneto transport and optical propagation in inhomogeneous media. Results of recent research on novel materials and respective methods of analysis were reported.

Group velocity depends on both refractive index and dispersion. Many exotic aspects of wave propagation occur in discontinuous media. ETOPIM5 featured spectroscopy methods and models and the savvy formalisms employed by physicists to describe and compute the properties of highly disordered composite or otherwise inhomogeneous media. Examples of the media discussed at ETOPIM5 include:

- metal films and 2-phase material composites
- thin-film metal-dielectric nanograin mixtures/nano-composites ("nanocermets").
- periodic dielectrics, heterostructures, and quantum dot systems
- granular structures and random systems
- disordered metals and metallic clusters
- porous media
- photonic band-gap structures

Photonic band-gap structures are of great interest. The photonic crystal may be useful for controlling light emission in diverse applications. The Hong Kong University of Science and Technology, for example, reported on sizable photonic band gaps in such structures. Their structures are composed of metallic-core spheres coated with a thin layer of high dielectric-constant (k) insulator. The existence of photonic crystals points to the possibility of achieving photonic band gaps in randomly-packed systems that would facilitate application in spectral regions not possible for naturally occurring crystals.

Regarding exotic behaviors, the classical Hall effect exhibited by semiconductors and some metals in a strong magnetic field engenders a strong anisotropy of optical properties in composites with these constitutuents. The behavior is particularly striking in thin metallic or semiconducting films with periodic microstructure. Also presented was work on optical properties of discontinuous metal films and films consisting of polarizable (embedded) spheres, and disordered systems that both scatter and amplify light -- so-called "random lasers."

Many of the methods reported are based on modifications to static and dynamic theories. A microscopic description tool for characterizing properties in amorphous semiconductors that possesses properties far different from their crystalline counterparts. Molecular dynamics are applied to determine metastable configurations, and then quantum theory is applied to predict properties. Other highlights from ETOPIM5's research topics include (1) mechanisms for quantum transport in porous low-k spin-glass systems, (2) quantum and interference phenomena, (3) magnetic nanostructures and magneto-resistance, and (4) elastic properties of inhomogeneous structures. Proceedings are expected in early 2000. (Maurice)

Conference: Sixth Symposium on Nano Device Technology (SNDT'99), Hsinchu, Taiwan, 12-13 May 99

SNDT'99 was hosted by the Nano Device Laboratories of the Taiwan National Science Council and held at the Microelectronics and Information Systems Research Hall of National Chiao Tung University in Hsinchu, Taiwan. The intensive two-day intensive symposium is a forum for the latest R&D in the area of nano-device technology. Highlights of this SNDT'99 include deep sub-1μm CMOS technology (trends on downsizing and its limitations), optical microlithography (status of 193 nm and 157 nm technology), dielectric materials (low-k for integration with copper interconnects), RF technology, and single electron transistors (SETs). The keynote speaker was NDL President Simon Sze; other speakers represented many leading microelectronics firms primarily from Asia and North America.

Topics which drew discussion:
Prof. Toshiro Hiramoto of the VLSI Design and Education Center, University of Tokyo, presented a plenary talk on the consequences of quantum confinement effects in silicon SETS. Though some SET devices can operate at room temperature, quantum-mechanical effects dominate their high-temperature operation. Further, a SET device having both n+ and p+ source/drain regions can act as both SET and SHT (a single "hole" transistor). Quantum effects have both advantages and disadvantages in SET structures. An advantage is that the operating temperature of a SET can be raised. A disadvantage is peak operating conditions become difficult to predict due to aperiodic oscillations that occur in the I-V (current-voltage) characteristic of the small structures at higher energies.

Proposed was SETs with Si nanocrystal dots as a means of providing better adjustments to operation with temperature change. Fabricated in the form of point contacts, the "dots" are Si nanocrystal and coupled-crystal structures. In discussions that followed, it was suggested that single-electron devices will become real when they are hybridized with CMOS, which cannot be further miniaturized, for room-T operation.

Optimization of Chemical Mechanical Planarization (CMP) processes: Designed to facilitate the fabrication of multilevel interconnections for increasingly complex, dense, and miniaturized devices and circuits, CMP is the process of smoothing and planing, aided by chemical etching, mechanical grinding, and one of the fastest growing, most important planarization technologies for advanced multilevel interconnects.

Appeals were made for East Asian countries, already strong in hardware, to pool together resources and talent to retain the hardware edge. Breakthroughs to solve upcoming next-century hardware limitations are projected to be architecture and algorithm related. (Maurice)

Site Visit: National Nano Device Labs (NDL) and Semiconductor Research Center (SRC) at National Chiao Tung University (NCTU), Hsinchu, Taiwan:

In recent years, Taiwan's semiconductor industry has become the powerhouse of its booming economy. Driven by rapid advancements in IC technologies and keen competition among its enterprises, the Hsinchu-local IC industry is a Taiwan miracle with 30% annual growth rate despite a global downturn. Among worldwide IC leaders - the US, Japan, and Taiwan - Taiwan has the healthiest growth. It is believed that Taiwan maintains such growth and a promising industry due to an infrastructure that is segmented, matrixed, and vertically integrated. The segments are independent companies. They are flexible and dynamic and thus capable of short cycle times and time-to-market. The development of Taiwan's semiconductor IC industry is further characterized by a certain solidarity. A close cooperation between academia and industry with industry providing funding to academia who, in turn, conduct research according to industry needs. Throughout the process, a high-caliber work force to serve the industry is trained.

To facilitate industry-academia joint research programs, NDL and the SRC are located within the campus of NCTU and neighbor Hsinchu's giant Science Based Industrial Park. Many of the elite and prominent executives in the world semiconductor IC industry were trained and graduated from NCTU. One of the world's finest technical universities, it ranks #1 in IEEE journal contributions, more than MIT, Stanford, and Berkeley. In 1995, NCTU led the world in papers contributed to the IEEE Journals Transactions on Electron Devices (IEEE-ED) and Electron Device Letters (IEEE-EDL).

NDL, founded by now-NCTU President C.Y. Chang, is one of the best-equipped and best-staffed research institutes in the world. Its present director is world-renowned semiconductor pioneer, Prof. Simon Sze, whose texts every student of the science is well acquainted with. Funded by Taiwan's National Science Council, it is one of 7 national research labs/institutes in Taiwan and the principal one devoted to the development of semiconductor IC manufacturing. The 21,350 ft^2 NDL facility is designed to meet the specific requirements of semiconductor microelectronic fabrication. It trains about 200 people annually, with 700 students in advanced-degree programs. In complement, and with objectives that are mostly educational, SRC trains about 500 graduate students per year. Staffed by full-time technicians, it also provides processing services.

NDL and SRC core technologies cover 1) deep sub-micron device technology, 2) microwave communication technology, and 3) advanced nano-device technology. Efforts center about the development of process module technologies and device integration. (Module technologies are, for example, optical and e-beam lithography, etching and chemical cleaning, deposition, growth, high-temperature processing, and characterization.) Because international collaboration is so easy to do in Taiwan, NDL and SRC technology experts are actively solicited from both home and abroad. Taiwan's semiconductor-related products industries include communication, information, consumer electronics, medical electronics, automation, energy and power systems. Taiwan is particular strong in *computer peripherals*, for which it is world leader. (Maurice)

Conference: 10th International Conference on Solid-State Sensors and Actuators (Transducers '99), Sendai, Japan, 7-10 June 99

Transducers '99 is a biennial conference focusing on theory, design, fabrication, and application of solid-state sensors, actuators, and microsystems. It is an interdisciplinary gathering with participants from university, government, and industrial laboratories representing a diverse cross spectrum of fields: electrical engineering, mechanical engineering, materials science, biomedical engineering, physics, biology, chemistry, and

microelectronics. With over 30 countries were represented, Transducers '99 had 212 oral presentation, 227 poster presentations, and 14 invited talks. A new session was added this year that focussed on biosensors and micro total analysis systems (μ-TAS), which are integrated fluidic systems for chemical analysis. This session attracted 53 papers, over 10% of the papers at the conference. Prof. Jed Harrison of the University of Alberta stated in his plenary talk that the "killer application" of micro-technology is genetic analysis, which he feels is the primary driver of micro-fluidics. The papers presented are listed on the conference home page: http://www.com.cas.uec.ac.jp/trans99.html. (Gaudreault)

Human Systems

News: Japan Air Self Defense Force (JASDF) Builds a New Human Centrifuge:

The JASDF Aeromedical Laboratory (AML) held the opening ceremonies for their new centrifuge facility located at Iruma Air Base on 14 April 1999. Iruma is located approximately one hour northwest of Tokyo. The centrifuge, manufactured by Shimadzu Corporation under license from Environmental Tectonics Corporation (ETC), is a gimbaled centrifuge with high G onset capability. With a 7.6 meter arm, the centrifuge is capable of onset rates of 6 G per second up to a maximum sustained G load of 12 G. The gondola is gimbaled with 3-axes of rotation. The configuration inside the gondola can be selected to simulate the F-15 or the F-2 (modified F-16) and can accommodate positive pressure breathing. The device is also well designed for data collection and research applications. The new Human Centrifuge System will be used both for pilot acceleration training and for AML research and development. Operational Test and Evaluation should be completed by April 2000. For more details contact the Acceleration Training Section, 4th Division, Aeromedical Laboratory (JASDF), 1-2-10 Sakae-cho, Tachikawa, Tokyo 190-8585, TEL: +81-42-524-4131. (Lyons)

Window on Science: Dr. Lim Kee Yong, Associate Professor, Nanyang Technological University (NTU), Singapore; visited the AFRL Human Effectiveness Directorate at Wright Patterson AFB, Ohio and the Warfighter Training Research Division at Mesa, Arizona, 24 May - 2 June 99

Dr. Lim is the Director of the Design Specialization Program and Deputy Director of the Design Research Center at Nanyang Technological University. His areas of expertise include equipment, workstation and user interface design including product and industrial ergonomics, human factors, and human computer interaction.

During this WOS visit Dr. Lim presented a colloquium on a methodology to provide a timely and effective input of human factors expertise into the design process. He has also authored a book on this subject "the MUSE Method for Usability Engineering". Areas of mutual interest with AFRL/HE include virtual design support for helmet mounted displays and validation of a virtual trainer for setting night vision goggles. Discussions also included problems of experimental design in the areas of adaptive interfaces with operator state/situational awareness, applications of multi-modal warnings, and display design.

Dr. Lim is chairing a 2000ASEAN conference in Singapore in 2000. For further information on this visit contact AOARD. (POC: Dr. Brian Tsou, AFRL/HEC) (Lyons)

Site Visit: Kyoto University, Saburo Matsui, Professor and Director, Research Center for Environmental Quality Control; 24 June 1999.

With a staff of 5 full-time professors, 1 visiting professor, and approximately 20 graduate students this Center conducts research in water pollution control in lakes and rivers, wastewater treatment, and toxic waste management at landfill sites. Recent work includes studies of natural fate and transport of pollutants, biodegradation, endocrine disrupters, and DNA strand breaks.

The Center will host the 3rd IAWQ Specialized Conference on Hazard Assessment and Control of Environmental Contaminants: ECOHAZARD '99 to be held 5-8 December 1999 in Otsu City, Japan. (http://www.eqc.kyoto-u.ac.jp/info/ecohazard.html). Dr. Matsui is the Chairman, Organizing Committee. (Lyons)

Site Visit: Institute of Industrial Science (IIS) at University of Tokyo, Roppongi, Tokyo, Japan; 3-4 June 99.

A research establishment of the University of Tokyo, the IIS has a staff of approximately 350 supplemented by over 450- graduate students and a budget (including salaries) of over 6.7 billion yen (1995). The IIS conducts an annual Open House in June. A considerable amount of man-

machine-interface research was embedded in this engineering research. In the Department of Electrical Engineering research topics included human computer interface using augmented reality. The 3D tracking of human hand movement using optical cameras was demonstrated. An interesting application to an "enhanced desktop" was demonstrated; a pan tilt camera and IR camera were used to track the operators hands performing both pointing and manipulation tasks. Patterns recognized by the computer would call up related information from the computer such as web sites then projected on to the desktop (Dr. Yoichi Sato).

Robotics research included robot-human communication, robot movement in an "intelligent space" (distributed intelligent network devices), and the development of an omni-directional robot equipped with an optical landmark tracking system. Another interesting demonstration was in the area of tele-nano robotics with tele-operation between the macro and the micro world. Nano-particles were manipulated using micro-fabrication cantilevers, an atomic force microscope, and deflection detection electronics. This system with 3D graphics and 1 DOF haptic display allows the manipulation by a human operator of 10-100 nanometer latex particles on a silicon surface (Dr. Hideki Hashimoto). Other robotics research included research and prototype development of underwater autonomous vehicles, multi-vehicle simulators, neural network based self-learning control systems for underwater robots, vision based object following, and the application of remotely operated unmanned vehicles for wreck surveying. Haptic devices, including a 7 DOF sensor arm and a 20 DOF sensor glove, with force sensors and force feedback were also demonstrated.

Applications to intelligent transportation systems included the development of personal smart transportation systems such as a parking assistance system which using sensor input from GPS, INS, and steering sensors to facilitate vehicle parking. Other applications included vehicle recognition using infrared images. Interdisciplinary research is being conducted on micro mechatronics including international collaborative work with the French National Center for Scientific Research (CNRS). Research areas include micro-actuators and their applications, micro-machining processes, and high precision measurement. Interesting presentations included artificial hearing by MEMS systems, artificial vision by MEMS systems (silicon retina), and bio-microsystems for cell manipulation and gene insertion.

The Center for Conceptual Processing of Multi-Media Information conducts research on databases, communication systems, super parallel computer architecture for conceptual processing and conceptual electronics. The International Center for Disaster-Mitigation Engineering (INCEDE) conducts research on disaster mitigation strategies including hydrological disaster and urban earthquake disaster mitigation engineering. The application of remote sensing to prediction of disaster situations is also being studied. Free services from the INCEDE to share lessons and experiences include a web page, an INCEDE Newsletter, and a series of Seminars (Dr. Srikantha Herath).

The IIS encourages international collaboration. Programs for international exchange include research and postdoctoral fellows (21 in 1997), visiting research assistants (11 in 1997) and post-graduate students (130 in 1997). Fellowships are also offered for visiting researchers. An International Conference on Intelligent Transportation Systems, co-chaired by the Director of the IIS, will be held in Tokyo, October 5-8, 1999. Although the research had stated applications to the commercial sector, the possible military applications of micro-machines, autonomous and remotely controlled systems is evident. http://www.iis.u-tokyo.ac.jp/ (Lyons)

Upcoming Conferences In Asia

These upcoming conferences may be of interest to you. Contact us for more details or check our homepage at http://www.nmjc.org/aoard/ Conferences in **BoldFace** are AFOSR/AOARD Sponsored.

Date	Name	Place
Sep 12-15, 99	The 4th Asian Pacific Conference on Medical & Biological Engineering	Seoul, Korea
Sep 14-16, 99	International Conference on Computer Communication 1999	Tokyo, Japan
Sep 20-24, 99	International Symposium on Precious Metals (ISPM'99)	Kunming, China
Sep 21-24, 99	1999 International Conference on Parallel Processing	Fukushima, Japan
Sep 21-24, 99	1999 Int'l Conference on Solid State Devices and Materials (SSDM'99)	Tokyo, Japan
Sep 23-26, 99	3rd Int'l Conf. on Computational Intelligence & Multimedia Applications	New Delhi, India
Sep 30-Oct 3, 99	AMSANZ Conference	Cairns, Queensland
Oct 5-8, 99	Intelligent Transportation Systems	Tokyo, Japan
Oct 6-8, 99	3rd Asia Pacific Congress of Aerospace Medicine	Chung-ju, Korea
Oct 12-13, 99	**Chitose International Forum on Photonic Sciences**	**Hokkaido, Japan**
Oct 12-15, 99	IEEE Conference on Systems, Man and Cybernetics (SMC'99)	Tokyo, Japan
Oct 13-15, 99	**JSASS 13th International Sessions in 37th Aircraft Symposium**	**Tokyo, Japan**
Oct 17-21, 99	International Conference on Intelligent Robots and Systems (IROS'99)	Kyongju, Korea
Oct 25-28, 99	3rd International Symposium on Control of Semiconductor Interfaces	Karuizawa, Japan
Oct 26-29, 99	International Conference on Advanced Robotics (ICAR'99)	Tokyo, Japan
Nov 1-5, 99	**Advanced High-Power Lasers and Applications (AHPLA99)**	**Osaka, Japan**
Nov 1-5, 99	**The 8th International Conference on Creep and Fracture of Engineering Materials and Structures (GFEMS-8)**	**Tsukuba, Japan**
Nov 1-5, 99	**9th International Conference on Ii-VI Compounds (II-VI'99)**	**Kyoto, Japan**
Nov 3-5, 99	**9th US-Japan Seminar on Dielectric and Piezoelectric Ceramics**	**Okinawa, Japan**
Nov 9-11, 99	**7th International Workshop on Rough Sets, Fuzzy Sets, Data Mining and Granular-Soft Computing**	**Yamaguchi, Japan**
Nov 14-19, 99	International Gas Turbine Congress	Kobe, Japan
Nov 15-17, 99	**International Conference on Composite Structures (ICCS 10)**	**Clayton, Australia**
Nov 17-19, 99	Science Frontier Tsukuba 999	Tsukuba, Japan
Nov 17-19, 99	International Topical Meeting on Microwave Photonics	Melbourne, Australia
Nov 18-19, 99	**Composite Specialist Workshop**	**Melbourne, Australia**
Nov 24-26, 99	**1999 Int'l Symposium on Micromechatronics and Human Science**	**Nagaoya, Japan**
Nov 29-Dec1, 99	Int'l Symposium on Surface Science for Micro & Nano-Device Fabrication	Tokyo, Japan
Nov 29-Dec 3, 99	**International Symposium on Photonics and Applications (ISPA'99)**	**Singapore**
Nov 30-Dec3, 99	Asia Pacific Microwave Conference (APMC)	Singapore
Dec 1-3, 99	The 6th International Display Workshops (IDW'99)	Sendai, Japan
Dec 5-8, 99	Ecohazard'99	Shiga, Japan
Dec 8-9, 99	**International Workshop on Fracture Mechanics and Advance Engineering Materials**	**Sydney, Australia**
Dec 15-17, 99	APCOM '99/4th Asia-Pacific Conf. on Computational Mechanics for the Next Millennium	Singapore
Jan 9-13, 00	Symposium on Energy Engineering in the 21st Century	Hong Kong
Mar 22-26, 00	Tokyo Aerospace 2000	Tokyo, Japan
Mar 27-30, 00	International Conference on Physiological and Cognitive Performance in Extreme Environments	Canberra, Australia

May 14-17, 00	The Fourth International Conference/Exhibition on High Performance Computing in Asia-Pacific Region (HPC-Asia 2000)	Beijing, China
May 23-26, 00	Advanced Underwater Technologies for the 21st Century	Tokyo, Japan
May 30-Jun 15, 00	International Conference on Role of Mesomechanics for Development of S&T Mini-Symposia on Use of Intelligent Material Computational Mechanics Composite Technologies	Xi'an, Beijing, Dalian, Shanghai, China
July 3-4, 00	**9th US-Japan Conference on Composite Materials**	**Shizuoka, Japan**
July 9-14, 00	**22nd International Symposium on Rarefied Gas Dynamics (RGD22)**	**Sydney, Australia**
July 11-14, 00	Fifth Optoelectronics and Communications Conference	Chiba, Japan
July 26-28, 00	**Photonic Taiwan 2000**	**Taipei, Taiwan**
Aug 16-18, 00	**4th International Conference on Fracture and Strength of Solids**	**Pohang, Korea**
Aug, 00	**Topical Workshop in Heterostructure Materials (TWHM'00)**	**Japan**
Aug 27-Sep 1, 00	26th International Congress on Occupational Health	Singapore
1 Oct, 00	**6th International Symposium on Polymer Electrolytes (ISPE6)**	**Australia**
Nov 19-23, 00	**International Conference on Communication Systems (ICCS'00)**	**Singapore**
Nov 29 Dec 1, 00	**2nd International Conference on Experimental Mechanics**	**Singapore**
May 14-18, 01	**Indium Phosphide and Related Materials, 2001 (IPRM'01)**	**Nara, Japan**
June, 01	**International Light Materials Conference (LiMat 2001)**	**Pusan, Korea**

Upcoming Window-on-Science Visitors

These upcoming Window-on-Science visits may be of interest to you. Contact us for more details or check our homepage at http://www.nmjc.org/aoard/aoardpa.html

Dates	Visitor Name	Affiliation and Country	Topic	Visit Location
6-9 Oct 99	Prof. Takafumi Yao	Tohoku University, Japan	High-quality Epitaxial Layers and Single Crystals	ZnO Workshop at AFRL/ML; AFRL/SN
6-13 Oct 99	Dr. Ippei Susuki	Seikei University Japan	Strength and Damage Tolerance of 3D Heat-Resistant Composites	AFRL/ML AFRL/VS (Kirtland)
6-13 Oct 99	Prof. Yasushi Miyano	Kanazawa Institute of Technology, Japan	Fatigue Life Prediction Methodology of Polymer Composites	AFRL/ML AFRL/VS (Kirtland)
6-13 Oct 99	Dr. Takashi Ishikawa	Nihon University Japan	Application of Ceramic Matrix Composite Using Si-Ti-C-O (Tyranno) Fiber	AFRL/ML AFRL/VS (Kirtland)
6-13 Oct 99	Prof. Yiu-Wing Mai	Univ. of Sydney Australia	Composite Fracture Machanics	AFRL/ML AFRL/VS (Kirtland)
6-13 Oct 99	Prof. Ian Marshall	Monash University, Australia	Effects of in-plane prestress on the impact damage tolerance of composite structures	AFRL/MLBC AFRL/VSDV

6-13 Oct 99	Prof. Kyung-Seop Han	Pohang Univerisity of S&T, Korea	Radar Absorbing Structures and Fatigue Damage and Impact Location Detection Using Fiber Optic Sensor or Other Recent Development in Composite Materials Including MMCs	AFRL/MLBC AFRL/VSDV
20-22 Oct 99	Prof. Masayoshi Esashi	Tohoku University, Japan	Precise Bulk Machining of Silicon for MEMS	AFRL/ML Workshop on Microsystems for Harsh Environments, Cleveland, OH
20-22 Oct 99	Prof. Hiroyuki Fujita	Tokyo University, Japan	Fabrication, System Integration and Applications of MEMS	AFRL/ML Workshop on Microsystems for Harsh Environments, Cleveland, OH
20-22 Oct 99	Prof. Susumu Sugiyama	Ritsumeikan University, Japan	High Aspect Ratio Micro-Mechanical Devices-Fabrication and Application	AFRL/ML Workshop on Microsystems for Harsh Environments, Cleveland, OH
28-29 Oct 99	Prof. Doh-Yeon Kim	Seoul National University, Korea	Abnormal Grain Growth Solid State Single Crystal Growth	AFOSR/NA AFRL/PRPE
28-29 Oct 99	Prof. Nong Moon Hwang	Seoul National University, Korea	Growth Mechanism of the CVD Diamond Process	AFRL/PRPE
28-29 Oct 99	Prof. Kaoru Shimamura	Okayama University, Japan	Scanning Prove Microscopy (SPM) of a rigid polymer crystal 3-dimensional Distribution of Polymer Chain Cillia	AFRL/ML
28-29 Oct 99	Prof. Kunio Kimura	Okayama University, Japan	Morphology Control of Rigid Polymers by Oligomer Phase Separation during Polymerization	AFRL/ML
28-29 Oct 99	Prof. Yuhiko Yamashita	Okayama University, Japan	Morphology Control of Rigid Polymers by Oligomer Phase Separation during Polymerization	AFRL/ML

Points of Contact at AOARD

7-23-17 Roppongi, Minato-ku, Tokyo 106-0032
Tel/Fax: +81-3-5410-4409/4407

Or

Unit 45002, APO AP 96337-5002
DSN: 315-229-3212
Fax: 315-229-3133

Dr. Koto White: *whiteko@aoard.af.mil*
Maj. Michele Gaudreault: *gaudream@aoard.af.mil*
Dr. Terence Lyons: *lyonst@aoard.af.mil*
Mr. Thomas Kim: kimt@aoard.af.mil
Ms. Joanne Maurice: mauricej@aoard.af.mil
Dr. Takao Miyazaki: miyazakit@aoard.af.mil
Dr. Jacquelinn Hawkins: hawkinsj@aoard.af.mil
Dr. Brett Pokines: pokinesb@aoard.af.mil
SSgt Michael Adams: adamsmi@aoard.af.mil

- *The ASL is also available at:* http://www.nmjc.org/aoard/Asia_Sci_Ltr_Dir.html. *All the web sites listed in the ASL are hyperlinked.*
- *Japanese to English translation is available to Air Force customers.*

Visit our Homepage
http://www.nmjc.org/aoard/